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Digitalna videoradiodifuzija (DVB) – Struktura okvirov, kodiranje kanalov in modulacija za satelitsko novinarstvo (DSNG) in druge prispevne aplikacije prek satelitov

Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for Digital Satellite News Gathering (DSNG) and other contribution applications by satellite

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Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for Digital Satellite News Gathering (DSNG) and other contribution applications by satellite

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Foreword

This European Standard (Telecommunications series) has been produced by the Joint Technical Committee Broadcast of the European Broadcasting Union (EBU), Comité Européen de Normalisation ELECtrotechnique (CENELEC) and the European Telecommunications Standards Institute (ETSI).

The work was based on the studies carried out by the European DVB Project under the auspices of the Ad Hoc Group on DSNG of the DVB Technical Module. This joint group of industry, operators and broadcasters provided the necessary information on all relevant technical matters (see bibliography).

NOTE: The EBU/ETSI JTC Broadcast was established in 1990 to co-ordinate the drafting of standards in the specific field of broadcasting and related fields. Since 1995 the JTC Broadcast became a tripartite body by including in the Memorandum of Understanding also CENELEC, which is responsible for the standardization of radio and television receivers. The EBU is a professional association of broadcasting organizations whose work includes the co-ordination of its members' activities in the technical, legal, programme-making and programme-exchange domains. The EBU has active members in about 60 countries in the European broadcasting area; its headquarters is in Geneva.

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Digital Video Broadcasting (DVB) Project

Founded in September 1993, the DVB Project is a marked-led consortium of public and private sector organizations in the television industry. Its aim is to establish the framework for the introduction of MPEG-2 based digital television services. Now comprising over 200 organizations from more than 25 countries around the world, DVB fosters marked-led systems, which meet the real needs, and economic circumstances, of the consumer electronics and the broadcast industry.

National transposition dates	
Date of adoption of this EN:	5 February 1999
Date of latest announcement of this EN (doa):	31 May 1999
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	30 November 1999
Date of withdrawal of any conflicting National Standard (dow):	30 November 1999

1 Scope

The present document describes the modulation and channel coding system (denoted the "System" for the purposes of the present document) for Digital Satellite News Gathering (DSNG) and other contribution applications by satellite.

According to ITU-R Recommendation SNG.770-1 [12], SNG is defined as "Temporary and occasional transmission with short notice of television or sound for broadcasting purposes, using highly portable or transportable uplink earth stations...". The equipment should be capable of uplinking the video programme (or programmes) with its associated sound or sound programme signals. Optionally it should be capable of providing two-way co-ordination (communication) circuits and data transmission according to EN 301 222 [6]. The equipment should be capable of being set up and operated by a crew of no more than two people within a reasonably short time. Limited receiving capability should be available in the uplink terminal to assist in pointing the antenna and to monitor the transmitted signal, where possible.

Digital television contribution applications by satellite consist of point-to-point or point-to-multipoint transmissions, connecting fixed or transportable uplink and receiving stations, not intended to be received by the general public.

Although these applications often transmit a single TV service, the Transport Stream multiplex flexibility also allows multi-programme TV services with associated sound, including commentary sound channels and data services; in this case multiple service components are Time Division Multiplexed (TDM) on a single digital carrier.

Maximum commonality with EN 300 421 [3] is maintained, such as Transport Stream multiplexing [1], scrambling for energy dispersal, concatenated error protection strategy based on Reed-Solomon coding, convolutional interleaving and inner convolutional coding. The baseline System compatibly includes (as a subset) all the transmission formats specified by EN 300 421 [3], based on Quaternary Phase Shift Keying (QPSK) modulation and is suitable for DSNG services as well as for other contribution applications by satellite. Nevertheless, other optional (annex C explains the meaning of "optional" within the present document) transmission modes are added, using Eight Phase Shift Keying (8PSK) modulation and Sixteen Quadrature Amplitude Modulation (16QAM), in order to fulfil specific application requirements. These optional modes can be very efficient in certain contribution applications by satellite.

The following warnings should be taken into account while using the high spectrum efficiency modes, 8PSK and 16QAM:

- they require higher transmitted EIRPs and/or receiving antenna diameters, because of their intrinsic sensitivity to noise and interferences;
- they are more sensitive to linear and non-linear distortions; in particular 16QAM cannot be used on transponders driven near saturation;
- they are more sensitive to phase noise, especially at low symbol rates; therefore high quality frequency converters should be used (see annex E);
- the System modulation/coding schemes are not rotationally-invariant, so that "cycle-slips" and "phase snaps" in the chain can produce service interruptions; therefore frequency conversions and demodulation carrier recovery systems should be designed to avoid cycle-slips and phase snaps.

The System is suitable for use on different satellite transponder bandwidths, either in single carrier per transponder or in multiple carriers per transponder (Frequency Division Multiplex, FDM) configuration. Annex E gives examples of possible use of the System.

The present document:

- gives a general description of the System;
- specifies the digitally modulated signal in order to allow compatibility between pieces of equipment developed by different manufacturers. This is achieved by describing in detail the signal processing principles at the modulator side, while the processing at the receive side is left open to different implementation solutions. However, it is necessary in the present document to refer to certain aspects of reception;
- identifies the global performance requirements and features of the System, in order to meet the service quality targets.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, subsequent revisions do apply.
- A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.

[1] ISO/IEC 13818-1: "Information technology; Generic coding of moving pictures and associated audio information: Systems".

[2] ISO/IEC 13818-2: "Information technology; Generic coding of moving pictures and associated audio information: Video".

[3] EN 300 421: "Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for 11/12 GHz satellite services".

[4] EN 50083-9: "Cabled distribution systems for television, sound and interactive multimedia signals; Part 9: Interfaces for CATV/SMATV headends and similar professional equipment for DVB/MPEG-2 transport streams".

[5] ETR 154: "Digital Video Broadcasting (DVB); Implementation guidelines for the use of MPEG-2 Systems, Video and Audio in satellite, cable and terrestrial broadcasting applications".

[6] EN 301 222: "Digital Video Broadcasting (DVB); Co-ordination channels associated with Digital Satellite News Gathering (DSNG)".

[7] Void.

[8] EN 300 468: "Digital Video Broadcasting (DVB); Specification for Service Information (SI) in DVB systems".

[9] ETS 300 327: "Satellite Earth Stations and Systems (SES); Satellite News Gathering (SNG) Transportable Earth Stations (TES) (13-14/11-12 GHz)".

[10] ETS 300 673 (1997): "Radio Equipment and Systems (RES); ElectroMagnetic Compatibility (EMC) standard for 4/6 GHz and 11/12/14 GHz Very Small Aperture Terminal (VSAT) equipment and 11/12/13/14 GHz Satellite News Gathering (SNG) Transportable Earth Station (TES) equipment".

[11] TBR 30: "Satellite Earth Stations and Systems (SES); Satellite News Gathering (SNG) Transportable Earth Stations (TES) operating in the 11-12/13-14 GHz frequency bands".

[12] ITU-R Recommendation SNG.770-1: "Uniform operational procedures for Satellite News Gathering (SNG)".

3 Symbols and abbreviations

3.1 Symbols

For the purposes of the present document, the following symbols apply:

α	Roll-off factor
C/N	Carrier-to-noise ratio
d_{free}	Convolutional code free distance
E_b/N_0	Ratio between the energy per useful bit and twice the noise power spectral density
f_N	Nyquist frequency
G_1,G_2	Convolutional code generators
I	Interleaving depth [bytes]
I, Q	In-phase, Quadrature phase components of the modulated signal
j	Branch index of the interleaver
K	Convolutional code constraint length
m	number of transmitted bits per constellation symbol
M	Convolutional interleaver branch depth for j = 1, M = N/I
N	Error protected frame length (bytes)
R_s	Symbol rate corresponding to the bilateral Nyquist bandwidth of the modulated signal
R_u	Useful bit rate after MPEG-2 [1] transport multiplexer, referred to the 188 byte format
T	Number of bytes which can be corrected in RS error protected packet
T_s	Symbol period
X,Y	Di-bit stream after rate 1/2 convolutional coding

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

16QAM	Sixteen Quadrature Amplitude Modulation
1CBPS	1 Coded Bit Per Symbol
2CBPS	2 Coded Bits Per Symbol
8PSK	Eight Phase Shift Keying
AWGN	Additive White Gaussian Noise
BER	Bit Error Ratio
BS	Bandwidth of the frequency Slot allocated to a service
BW	Bandwidth (at -3 dB) of the transponder
CBPS	Coded Bits Per Symbol
DSNG	Digital Satellite News Gathering
FDM	Frequency Division Multiplex
FEC	Forward Error Correction
HEX	Hexadecimal notation
IF	Intermediate Frequency
IRD	Integrated Receiver Decoder
MCPC	Multiple Channels Per Carrier transmission
MPEG	Moving Pictures Experts Group
MUX	Multiplex
OBO	Output Back Off
OCT	Octal notation
P	Puncturing
PDH	Plesiochronous Digital Hierarchy
PSK	Phase Shift Keying
QEF	Quasi-Error-Free
QPSK	Quaternary PSK
RF	Radio Frequency
RS	Reed-Solomon
SCPC	Single Channel Per Carrier transmission
SI	Service Information

SMATV	Satellite Master Antenna Television
SNG	Satellite News Gathering
TCM	Trellis Coded Modulation
TDM	Time Division Multiplex
TSDT	Transport Stream Descriptor Table
TV	Television

4 Transmission system

4.1 System definition

The System is defined as the functional block of equipment performing the adaptation of the baseband TV signals, from the output of the MPEG-2 transport multiplexer (see ISO/IEC 13818-1 [1]), to the satellite channel characteristics. The System is designed to support source coding as defined in [1], [2], [5].

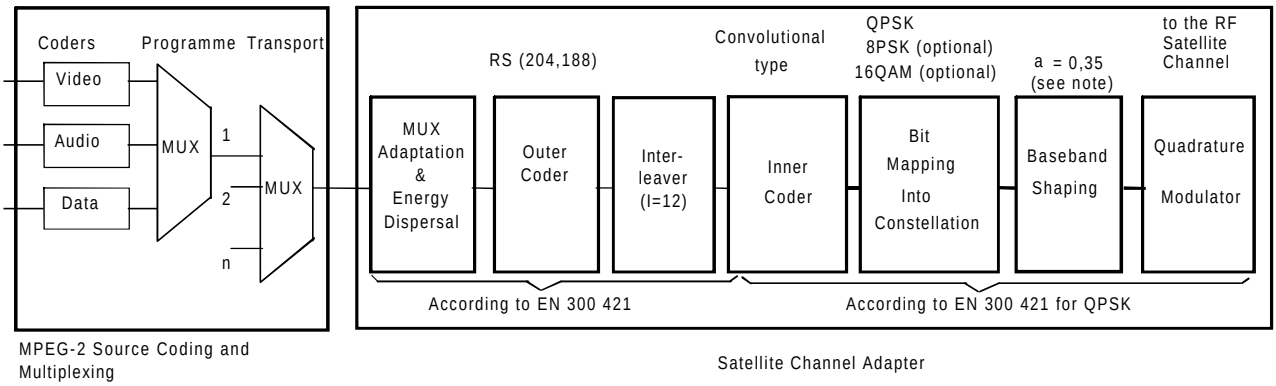
The System transmission frame is synchronous with the MPEG-2 multiplex transport packets (see [1]).

The System shall use QPSK modulation, and optionally (annex C explains the meaning of "optional") 8PSK and 16QAM modulations, and the concatenation of convolutional and RS codes. For 8PSK and 16QAM, "pragmatic" trellis coding shall be applied, optimizing the error protection of the convolutional code defined in EN 300 421 [3]. The convolutional code is able to be configured flexibly, allowing the optimization of the system performance for a given satellite transponder bandwidth (see annex E).

Digital television transmissions via satellite can be affected by power limitations, therefore ruggedness against noise and interference has been one of the design objectives of the System. On the other hand, when larger power margins are available, spectrum efficiency can be increased to reduce the cost of the space segment. Therefore the System offers many transmission modes (inner coding and modulations), giving different trade-offs between power and spectrum efficiency. For some specific contribution applications, some modes (QPSK and 8PSK) thanks to their quasi-constant envelope, are appropriate for operation with saturated satellite power amplifiers, in single carrier per transponder configuration. All the modes (including 16QAM) are appropriate for operation in quasi-linear satellite channels, in multi-carrier Frequency Division Multiplex (FDM) type applications.

The following processes shall be applied to the data stream (see figure 1):

- transport multiplex adaptation and randomization for energy dispersal (according to EN 300 421 [3]);
- outer coding (i.e. Reed-Solomon) (according to EN 300 421 [3]);
- convolutional interleaving (according to EN 300 421 [3]);
- inner coding:
  - punctured convolutional coding (according to EN 300 421 [3]);
  - "pragmatic" trellis coding associated with 8PSK and 16QAM (optional);
- bit mapping into constellations:
  - QPSK (according to EN 300 421 [3]);
  - 8PSK (optional);
  - 16QAM (optional);
- squared-root raised-cosine baseband shaping:
  - roll-off factor $\alpha = 0,35$ according to EN 300 421 [3] for QPSK, 8PSK and 16QAM;
  - additional optional roll-off factor $\alpha = 0,25$ (for the optional modulations 8PSK and 16QAM);
- quadrature modulation (according to EN 300 421 [3]).



NOTE: α = 0,25 for 8PSK and 16QAM (additional and optional).

Figure 1: Functional block diagram of the System

If the received signal is above C/N and C/I threshold, the Forward Error Correction (FEC) technique adopted in the System is designed to provide a "Quasi Error Free" (QEF) quality target. The QEF means less than one uncorrected error-event per transmission hour, corresponding to Bit Error Ratio (BER) = 10^{-10} to 10^{-11} at the input of the MPEG-2 demultiplexer.

4.2 Adaptation to satellite transponder characteristics

The symbol rate shall be matched to given transponder characteristics, and, in the case of multiple carriers per transponder (FDM), to the adopted frequency plan. Examples of possible use of the System are given in annex E.

4.3 Interfacing

The System, as defined in the present document, shall be delimited by the following interfaces given in table 1.

Table 1: System interfaces

Location	Interface	Interface type	Connection
Transmit station	Input	MPEG-2 [1], [2], [4] transport multiplex (note 1)	from MPEG-2 multiplexer
	Output	70/140 MHz IF, L-band IF, RF	to RF devices
Receive installation	Output	MPEG-2 transport multiplex [1], [2], [4] (note 1)	to MPEG-2 demultiplexer
	Input	70/140 MHz IF, L-band IF	from RF devices
NOTE 1: For interoperability reasons, the Asynchronous Serial Interface (ASI) with 188 bytes format, data burst mode (bytes regularly spread over time) is recommended. NOTE 2: The 70 MHz IF may imply limitation on the maximum symbol rate.			

4.4 Channel coding for QPSK modes

The information on QPSK modulation summarized here is only partial. Refer to EN 300 421 [3] for the complete specification.

4.4.1 Transport multiplex adaptation and randomization for energy dispersal

This processing shall be in accordance with EN 300 421 [3], as summarized in the following.

The System input stream shall be organized in fixed length packets, following the MPEG-2 transport multiplexer (see ISO/IEC 13818-1 [1]). The total packet length of the MPEG-2 transport Multiplex (MUX) packet is 188 bytes. This includes 1 sync-word byte (i.e. 47_{HEX}). In order to comply with ITU Radio Regulations and to ensure adequate binary transitions, the data of the input MPEG-2 multiplex shall be randomized. To provide an initialization signal for the descrambler, the MPEG-2 sync byte of the first transport packet in a group of eight packets is bit-wise inverted from 47_{HEX} to $B8_{HEX}$. This process is referred to as the "Transport Multiplex Adaptation".

4.4.2 Outer coding (RS), interleaving and framing

This processing shall be in accordance with EN 300 421 [3], as summarized in the following.

Reed-Solomon RS (204,188, T = 8) shortened code, from the original RS(255,239, T = 8) code, shall be applied to each randomized transport packet (188 bytes) to generate an error protected packet. Reed-Solomon coding shall also be applied to the packet sync byte, either non-inverted (i.e. 47_{HEX}) or inverted (i.e. $B8_{HEX}$).

Convolutional interleaving with depth I = 12 shall be applied to the error protected packets. This results in an interleaved frame, composed of overlapping error protected packets and delimited by inverted or non-inverted MPEG-2 [1] sync bytes (preserving the periodicity of 204 bytes).

4.4.3 Inner coding (convolutional)

Processing of the convolutional encoder shall be in accordance with EN 300 421 [3], as summarized in the following.

The System shall allow for a range of punctured convolutional codes, based on a rate 1/2 mother convolutional code with constraint length K = 7 corresponding to 64 trellis states (figure 2). This will allow selection of the most appropriate level of error correction for a given service or data rate. The System shall allow convolutional coding with code rates of 1/2, 2/3, 3/4, 5/6 and 7/8.

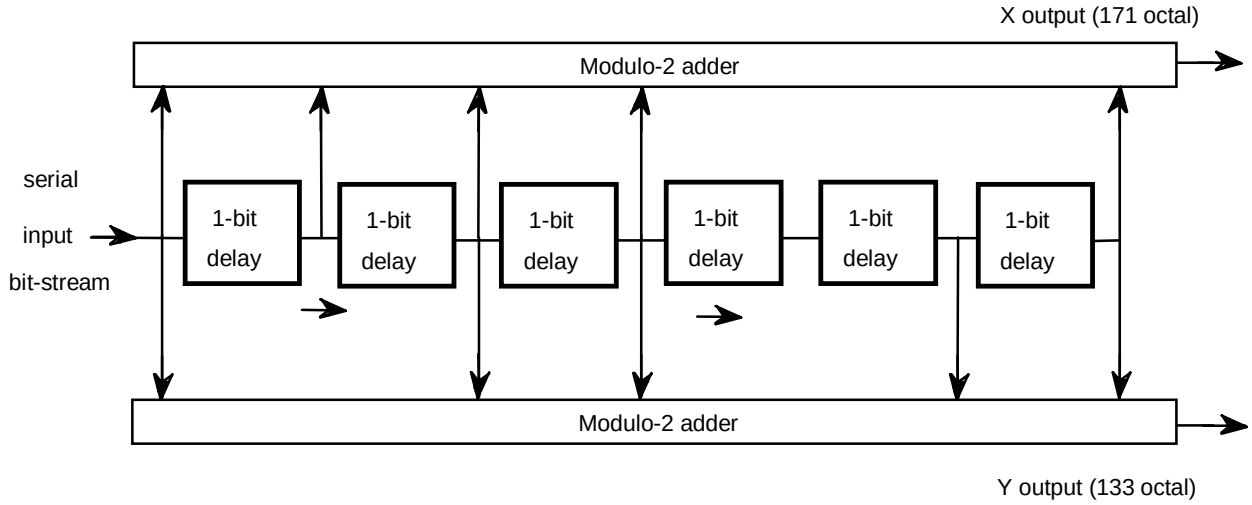


Figure 2: Convolutional code of rate 1/2

The punctured convolutional code shall be used as given in table 2, according to EN 300 421 [3].

NOTE: At the receiver, each of the code rates and puncturing configurations is in a position to be tried until lock is acquired. Phase ambiguity in the demodulator is able to be resolved by decoding the MPEG-2 [1] sync byte delimiting the interleaved frame. Automatic receiver synchronization is an important feature in DSNG applications, to simplify and accelerate the satellite connection setup.